Total Maximum Daily Load
For Pesticides (Atrazine)
West Lake (Osceola)
Clarke County, Iowa

August 8, 2002

Iowa Department of Natural Resources
Water Resources Section

TMDL for Pesticides (Atrazine)
West Lake (Osceola)
Clarke County, Iowa

Waterbody Name:	West Lake (Osceola)
IDNR Waterbody ID:	IA 04-LDM-02690-L
Hydrologic Unit Code:	HUC10 1000080902
Location:	Sec. 13, T72N, R26W
Longitude:	93 Deg. 48 Min. 37.14N
Latitude:	41 Deg. 1 Min. 56.54 W
Use Designation Class:	B (LW) (aquatic life) C (drinking water)
Watershed Area:	6,350 acres
Lake Area:	302 acres
Major River Basin:	Des Moines River – South River Basin
Tributaries:	South Squaw Creek
Receiving Water Body:	South Squaw Creek
Pollutant:	Pesticides (Atrazine)
Pollutant Sources:	Agricultural Nonpoint
Impaired Use:	Drinking Water
1998 303d Priority:	High

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1. Introduction

The Federal Clean Water Act requires the Iowa Department of Natural Resources (DNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. West Lake (Osceola) was listed as partially supporting its drinking water uses due to exceeding the water quality standard (WQS) for the pesticide (herbicide) atrazine. The TMDL for West Lake (Osceola) calculates the maximum amount of pesticide (atrazine) that can be delivered to the lake and still allow it to maintain a concentration lower than the water quality standard value of 3 ìg/L. The maximum amount, or load, will then be allocated to watershed sources.

Specifically this pesticide (atrazine) TMDL for West Lake (Osceola) will:

- Identify the adverse impact that pesticide (atrazine) is having on the designated use of the lake.
- Describe how the concentration of pesticide (atrazine) in the lake often violates the water quality standard.
- Identify a target condition and load that assures the designated use will be achieved.
- Calculate an acceptable pesticide (atrazine) load, including a margin of safety.
- Allocate the acceptable load to all the sources.
- Provide implementation guidance for DNR staff and watershed stakeholders to achieve designated use goals.

As stated above, the pesticide that caused the impairment at West Lake (Osceola) is atrazine. Atrazine is highly soluble by design so that it can move with water into plants through their roots. This same high solubility also allows it to be conveyed by overland runoff to streams that discharge into the lake. Timing of application, rainfall duration and intensity, vegetative cover, and ground moisture are all important transport factors and the delivered load is determined by herbicide availability during rainfall. Water clarity, pH, temperature, amount of dissolved organic carbon, and depth affect residence time in the water column. There is evidence that bottom sediments adsorb some atrazine.

In order to accomplish the goals of this TMDL, a phased approach will be used. Phase I of this pesticide (atrazine) TMDL for West Lake (Osceola) establishes the allowable atrazine load to the lake as zero for the period January 2003 through December 2004. This load restriction will begin to reduce the atrazine concentration in the lake to 3 ìg/L or below to meet the target concentration and meet the water quality standard (WQS). Phase II will be to evaluate the data gathered through continued monitoring to assess the effectiveness of the Phase I load restriction in eliminating the water quality standard violation in the lake. Ultimately, the intent of this TMDL is to restore and maintain the atrazine concentration in the raw water to at or below the WQS of 3 ìg/L. The phased approach allows DNR to utilize a feedback loop to determine if the initial atrazine load restriction has been effective and to develop a scenario at a later date that would allow for some atrazine delivery to the lake.

2. Description of Waterbody and Watershed

West Lake (Osceola) is located in Clarke County two miles west of Osceola. The 302-acre lake was constructed in 1933 and 1934 to serve as a source of potable water for the city. The lake's dam has been raised several times, most recently in 1983. The current maximum volume is 4,210 acre-feet. Although the City of Osceola is not located within the watershed, West Lake (Osceola) is the primary water source for the city as well as for many of the watershed residents. As a water supply it is utilized near its total capacity.

Lakeside Casino Resort, located on the north edge of West Lake (Osceola), was constructed in 1999, and opened for business January 1, 2000. The casino owns 107 acres within the watershed and leases another 1,440 acres from the city located east and south of West Lake (Osceola). Most of the leased land remains in timber or grassland. The casino has 1 million visitors annually and has 500 to 600 employees. Retention structures have been built at the Casino to protect the lake from runoff from the parking and grassed areas surrounding the buildings.

The West Lake (Osceola) watershed has an area of 6,350 acres and has a watershed-to-lake ratio of 21:1. This ratio is considered well within an acceptable range for good lake management by the DNR.

Table 1. 2001 land use data for West Lake (Osceola) watershed.

Landuse	Area in Acres	Percent of Total Area
Cropland	3571	56
Pasture	1100	17
Timber and Wildlife	685	11
Lakeside Casino	107	2
Other (Roads, farmsteads)	887	14
Total	6,350	100

The soils of the watershed are of the Gara-Armstrong-Pershing Association (USDA-SCS, 1989), described as gently sloping to steep, moderately well drained and somewhat poorly drained, loamy and silty soils formed in glacial till, in loess or sediments overlying a paleosol, and in loess. In most areas the landscape is undulating to steep, and slopes range from 2 to 25%. The surface layer (7-8 inches) ranges from dark gray to very dark grayish brown, friable loam. This association is used mainly for permanent pastures and hay, with the gently sloping to moderately sloping areas being used for cultivated crops. The Soil Survey of Clarke County, Iowa suggests using "a system of conservation tillage that leaves crop residue on the surface, contour farming, a cropping rotation that includes grasses and legumes, and terraces to help prevent excessive soil loss" (USDA-SCS, 1989).

Average rainfall in the area in the period from 1990 to 2001 (Appendix II, Table D), was 41 inches per year, with the greatest monthly amount (5.4 inches each month) occurring in May, June and July. Half of the annual rainfall occurs from April through July (20.4 inches).

In 1991, a watershed project was instituted to address sediment, nutrients, and pesticide loss. It was believed that controlling the sediment loss would control atrazine levels in the lake. Although a drop in atrazine levels was noted, the overall goal of reaching and maintaining raw water concentrations below the WQS was not achieved. It is to be noted that the reductions in sediment loading to the lake and a drop in nutrient levels supporting large-scale algal blooms have greatly improved water clarity. The lake is not listed for aquatic life impairment. DNR Fisheries reports that the watershed project efforts have greatly improved the quality of the fishery.

3. Applicable Water Quality Standards

As stated in 567 Iowa Administrative Code 61 (567 IAC 61), the numeric water quality standard (WQS) for atrazine is 3 ìg/L based on the Environmental Protection Agency's (EPA) drinking water maximum contaminant level (MCL) of 3 ìg/L. The MCL is calculated as a four quarter running average for determining compliance with the Class C standards. In the 1992 DNR

biennial water quality 305(b) report, the drinking water use (Class C) for West Lake (Osceola) was assessed as partially supported due to high levels of atrazine in sediment samples taken near the dam. Surveys conducted by University Hygienic Laboratory (UHL) on water supply reservoirs in Iowa suggested that the high atrazine concentrations in sediment resulted from high spring / summer levels of atrazine in the water column. The 1992 listing was based on information collected during the 1990-1991 period.

Data collected in March, 1992 (Miller & Kennedy); 1993 (DuPont); 1995 (Miller & Kennedy); 1994-present (Novartis Crop Protection, Inc., / Syngenta Crop Protection, Inc.); and 1994-present (Osceola) all have been used for subsequent reporting periods.

4. Water Quality Conditions

Numerous Water Quality studies have been conducted at West Lake (Osceola). Those studies include the Clean Lakes Classification Study by Iowa State University (ISU, 1992); the 1990 Clean Lakes Study (UHL); and the UHL Water Supply Reservoir studies in 1993 and 1995. Currently, in-lake water monitoring will be completed as part of the Iowa Lakes Survey, which includes sampling three times per year for each of the field seasons 2000 – 2005.

Under a program coordinated between Novartis Crop Protection, Inc. (now Syngenta CPI) and the city of Osceola, samples for atrazine have been taken bimonthly since May, 1994, with weekly sampling implemented in the May through July period. That data is submitted annually to DNR. The data from this program and plots of daily precipitation and atrazine concentrations in the lake water are in Appendix II.

Raw water samples have frequently exceeded the standard. A granular activated carbon (GAC) layer has been added to the filters at the drinking water treatment plant to remove the atrazine from the raw water. Due to the levels of atrazine in West Lake Osceola, the carbon layer must be changed annually.

5. Desired Target

The desired target for West Lake (Osceola) is to maintain an in-lake atrazine concentration equal to or less than the water quality standard of 3 ìg/L.

6. Loading Capacity

The loading capacity of West Lake (Osceola) for atrazine is the maximum mass of atrazine that can be delivered to the lake and still allow it to meet the water quality standard. The loading capacity is dependent upon the target water quality standard, the initial (antecedent) lake volume, and atrazine concentration.

The water quality standard is 3 ìg/L, as per 567 IAC 61.

The critical antecedent lake volume for calculating the loading capacity is the lowest volume in the operating range. Table E in Appendix II contains the volume data for the lake at different water surface elevations. The volume data was obtained from the Osceola Water Board (Duben, 2002). According to water treatment plant operator, the normal operating range is from the top of the overflow to six feet below. These elevations are 1,072 and 1,066 feet and the corresponding volumes are 4,210 and 2,596 acre-feet. The critical volume for load capacity calculations is then 2,596 acre-feet or 846 million gallons (MG).

The antecedent atrazine concentration varies with time. The following table, and the resulting loading capacities (at the critical volume), show assumed antecedent in-lake concentrations

ranging from no atrazine present in the lake to the WQS concentration of 3 ìg/L, the corresponding mass of atrazine in the lake, and the resulting loading capacities at the critical volume.

Table 2. Lake Atrazine Loading Capacity

Antecedent lake atrazine concentration (ìg/L)	Mass of atrazine existing in the lake at given antecedent in-lake concentration (pounds)	Loading capacity: Mass of additional atrazine deliverable to the lake while still meeting WQS (pounds)
0	0	21.2
0.5	3.5	17.6
1	7.1	14.1
1.5	10.6	10.6
2	14.1	7.1
2.5	17.6	3.5
3	21.2	0

7. Pollutant Sources

Atrazine is applied in the West Lake (Osceola) watershed predominantly by agriculture and, in general, atrazine is only applied to corn crops in May and June. Potential transport mechanisms include overland runoff, direct rainfall to the lake containing low levels of dust, and drainage tile discharge containing atrazine from infiltration. Due to the nature of the predominant soil types in the watershed, the main source is the atrazine carried from application sites by overland runoff to the receiving water body.

8. Pollutant Allocation

TMDL development requires the allocation of the West Lake (Osceola) atrazine loads to point and non-point sources.

8.1 Point Sources Wasteload Allocation:

There are no point source discharges for atrazine within the West Lake (Osceola) watershed, therefore the Wasteload Allocation established under this TMDL is zero.

8.2 Non-Point Source Load Allocation:

All atrazine in West Lake (Osceola) comes from non-point source discharges.

The load allocation for Phase I is set at zero for the period of January 2003 through December 2004, based on the following:

Tables A and B in Appendix I show the measured atrazine concentrations in West Lake (Osceola) for 2000 and 2001, respectively. Using the data for the 2000 and 2001 calendar years (Table C, Appendix I), the running four-quarter average of atrazine concentrations meets or exceeds the WQS of 3 ìg/L. All measurements for 2000 showed the atrazine concentration at or above 2.6 ìg/L. For 2001, numerous individual measurements were more than double the water quality standard. It is apparent from the data that any atrazine delivered to the lake in the near term will cause or prolong a water quality standard violation.

Long term data (Charts 1-4) shows that despite normal expected variability in factors affecting in-lake atrazine concentrations (weather, application rates, lake water levels, etc), concentrations in the lake rise above the WQS for periods of time in at least every other year.

More recently, the WQS has been violated in every year. It is apparent from the data that the load allocation for Phase I of 0 ìg/L must extend for at least two years.

For Phase II, load allocations can be based on verifiable antecedent lake atrazine concentrations. For Phase II, a margin of safety should be incorporated into the load allocations. Table 3 shows load allocations based on antecedent concentrations over the range of 0 ìg/L up to a chosen maximum allowable concentration. The chosen maximum allowable concentration for Phase II load allocations is 2.6 ìg/L and is derived from the numeric water quality standard (3 ìg/L) and a margin of safety. The margin of safety is established as 0.4 ìg/L to allow for analytical error and background variability, as described in Section 8.3.

Table 3. Lake Atrazine Load Allocations

Antecedent lake atrazine concentration, ìg/L	Load allocation: Allowable pounds of atrazine deliverable to the lake during application season
0	18.3
0.5	14.8
1	11.3
1.5	7.8
2	4.2
2.5	0.7
2.6	0

8.3 Margin of Safety

A margin of safety has been incorporated into the TMDL in the following ways:

- The 2.6 ìg/L atrazine concentration value used to develop the maximum loads is 17% lower than the 3 ìg/L WQS limit. This allows for monitoring analytical error (plus or minus 15%) and background variability.
- The minimum lake operating volume has been used to generate all of the maximum atrazine loads.
- The factors reducing antecedent atrazine concentrations:
  1) rainfall dilution,
  2) water outflow (overflow, usage, and evaporation), and
  3) atrazine degradation;

  have been assumed to be negligible on an annual basis compared to the factors increasing the atrazine concentration.

9. Seasonal Variation

Atrazine is applied in the watershed in May or June when the probability of rain is high. Soon after a rainfall event, monitoring data during these months show atrazine concentrations in the lake increase sharply. Atrazine concentrations in the lake increase throughout May and/or June, level out through July and August, and then slowly decrease by dilution, degradation, and outflow until the next application season. A three or four inch rain during any time outside the application season can produce an observable decline in the lake atrazine concentration. The high concentration water is displaced by water containing small amounts of the chemical, changing the overall concentration. This dilution effect, the sharp concentration rise after the normal application season, and the gradual decline in concentration are reflected in the plots of daily precipitation and monitored atrazine concentrations found in the Charts in Appendix II.

10. Monitoring

Under a program coordinated between Novartis Crop Protection, Inc. (now Syngenta CPI) and the city of Osceola, samples for atrazine have been taken bimonthly since May, 1994, with

weekly sampling implemented in the May through July period. That data is submitted annually to DNR. This program is part of the Voluntary Monitoring Program (VMP) coordinated through Syngenta CPI and EPA as part of the re-registration process for atrazine. The VMP participants will continue to monitor this lake throughout the life of this TMDL. The current monitoring frequency will be continued, but the analyses have been extended to include atrazine and three of its metabolites (Tierney, 2002).

Metabolites are the secondary products created as a compound starts to degrade, or metabolize. Atrazine is metabolized into three chlorinated atrazine compounds: desethylated atrazine (DEA), desisopropyl atrazine (DIA), and diamnochlorotriazine (DACT). The chlorinated atrazine compounds are considered to be equal in toxicity to atrazine (EPA, 2002), and have therefore been included in all of Syngenta's VMP plans for Community Water Supply monitoring.

11. Implementation

The existing TMDL rules do not require implementation plans. The following discussion can provide guidance to those interested in improving water quality in the lake.

The following difficulties need to be resolved if atrazine application is to have minimal impact on the lake:

- How to protect atrazine from rainfall until it is absorbed into plants.
- How to prevent the fraction of atrazine not used by the plant from getting to the lake.
- How to remove quickly the atrazine that reaches the water column.

The goal of implementation is to meet the load allocations established in this TMDL, which are designed to bring the lake into compliance with established water quality standards. Application practices within the watershed should be inventoried to improve understanding and assessment of the problem. Application timing and the relationship to changes in-lake concentrations need to be further evaluated. The relative contributions of major atrazine delivery mechanisms (overland runoff from rainfall events and tile terraces that are direct conduits to streams and the lake) must be assessed. These activities will help to determine what watershed management approaches will have the desired impact.

Research from Iowa State University has shown that between 1 and 5 percent of atrazine applied to cropland is lost (Baker and Mickelson, 2002). Based on personal conversations with the researchers, an expected delivery of atrazine to West Lake (Osceola) of about 3 percent of the amount applied, due to the soil type, topography, and tile drainage of the area. For example, if no atrazine is present in the lake, available information indicates that 610 pounds of atrazine (18.3 is 3 percent of 610) could be applied to cropland without the atrazine delivery to the lake exceeding the load allocation. Further, if 2.6 ìg/L of atrazine is present in the lake, no atrazine can be delivered to the lake without exceeding the load allocation shown in Table 3, Section 8.2. Any additional atrazine delivered to the lake with that 2.6 ìg/L antecedent concentration would cause a water quality violation.

Table 4 below shows watershed target loads (amount of atrazine that can be applied to cropland in the watershed) for the range of load allocations as described in Table 3.

Table 4. Watershed Target Loads

Antecedent lake atrazine concentration (ìg/L)	Load allocation: Allowable pounds of atrazine deliverable to the lake during application season	Target load for watershed: Total mass in pounds that can be applied (assumes 3% of application will be delivered to the lake water column)
0	18.3	611
0.5	14.8	494
1	11.3	376
1.5	7.8	259
2	4.2	141
2.5	0.7	24
2.6	0	0

The National Resource Conservation Service (NRCS) in Clarke County has applied for a Watershed Protection Plan Development grant to address plans for improving water quality in the West Lake (Osceola) watershed. However, due to budget constraints this year in Iowa, that money may not be available, and notification has been delayed. In addition, many stakeholders in and out of the watershed have formed a coalition to propose solutions to the atrazine problem. Funds to assist in the development of best management practices in the watershed may be available through the Division of Soil Conservation and EPA Section 319 funding sources. Projects funded by Section 319 grants are subject to the provisions of the Endangered Species Act.

12. Public Participation

Public meetings regarding the procedure and timetable for developing the West Lake (Osceola) pesticide (atrazine) TMDL were held on January 14, 2002, in Des Moines, Iowa; and on January 29, 2002 at American State Bank in Osceola, Iowa. Another meeting was held June 4, 2002, at Southwestern Community College in Osceola to discuss the draft document. The public comment period for this TMDL was from May 31, 2002 to July 1, 2002. Appropriate comments have been incorporated into the West Lake (Osceola) Pesticide (atrazine) TMDL prior to submittal to EPA for final approval.

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